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Quarterly Progress Report No. 4
For the period July 1 to September 30, 1960

DEVELOPMENT OF HIGH ENERGY BATTERIES

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Introduction

A research program on the development of high energy batteries utilizing a reactive metal such as sodium or lithium is being carried out at Stanford Research Institute for NASA. Batteries are used in powering much of the guidance, control, and electronic measuring equipment in missiles and space probes, and the properties of batteries are presently a major limiting factor in the useful life of an earth satellite. An improvement in battery characteristics, such as weight-per-unit energy output, would extend the useful period of operation of satellites. It is toward this goal that the present research is directed.

During the previous quarter the 14th Annual Signal Corps Power Source Conference was attended. Ideas relating to nonaqueous-solution cells were found in discussions given on ammonia-system batteries and inorganic depolarized dry cells. The ammonia battery system can use sulfur as a cathode material; the sulfur can be thought of as reacting with liquid ammonia to form a nitrogen-sulfur compound which is electrochemically reactive, or sulfur can react by transfer from the cyanide ion to the thiocyanate ion and subsequently be reduced.

During the present quarter work was centered on lithium as the anode and the use of cathode coating materials other than Halane. Polarization studies were also continued.

Experimental Work

It was observed that the potential of a platinum reference electrode versus the lithium anode remained practically unaffected while the terminal voltage dropped to zero. This indicates that under our experimental conditions the main limitation of the cell is in the Halane cathode rather than in the lithium anode. It is believed that the difficulties with the Halane electrode are caused by the formation of a gaseous (chlorine) or solid (parathiocyanogen) resistive layer which interferes with the contact between the carbon grains and the active material. In some cases a poorer discharge behavior was observed with the lithium strip alone than when the lithium was backed by a copper plate. This could be due to the smaller pressure exerted by the rubber bands in the former case. If this is so, the cell's performance would depend on the pressure between the electrodes, just as is the zinc electrode in the silver-zinc battery.

Other cathode materials were investigated. These included copper oxide-graphite mixtures, cuprous sulfide, and Dibromantin-graphite; soluble copper salts, such as CuF_2 and $CuCl_2$, were mixed with graphite and placed in a paste form on graphite; sulfur-graphite and potassium cyanide, silver peroxide, and silver metal on silver mesh were also tried. Further cell runs were made using $KICl_4$ as cathode material. The preparation of this compound was described in Quarterly Progress Report No. 3. Open circuit voltages obtained ranged from 3.1 to 3.8 volts with currents from 10 to 470 milliamperes. In cell-capacity runs $KICl_4$ was rated at 1,250 ma-min, with a 3.0 closed circuit voltage. This is equivalent to a capacity of 0.21 watt-hr/lb. Similarly constructed Halane cathode cells exhibited 270 ma-min at 3.05 closed-circuit voltage, approximately one-fifth capacity of the $KICl_4$ cell. Filter paper was used as the separator in these experiments.

A microporous polyvinyl chloride resin* sheet 0.008 inch thick was used as a membrane material and showed good strength, nonswelling, and insolubility in propylene carbonate solutions. It therefore offers promise for use in future cell studies.

Double cell (bipolar) construction was also investigated. A typical cell showed open circuit voltage of 6 volts and 225 milliamperes current. Electrode area was 35 cm^2; cathodes were made by the pressed cake method. This type of cell construction shows considerable merit because of weight saving that could be obtained compared with single cell arrangement.

Future Work

Studies will be continued in an effort to determine the factors causing excessive polarization at the Halane cathode. Lithium anodes will be prepared by coating molybdenum sheets with molten lithium

*"Pormax," Electric Storage Battery Company.

using cathode materials such as Ag_2O_2 and other oxidizing agents. Polarization time curves will also be taken to ascertain the type of potential decay curve obtained after the cell has been loaded with a resistance and subsequently opened.

The Final Report which will contain results in tabular and graph form is being prepared.

Expenditures

A summary of expenditures for the period July 1 to September 30, 1960 is appended.

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Attachment

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